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International Science and Engineering Partnerships:

A Priority for U.S. Foreign Policy and Our Nation's Innovation Enterprise

DRAFT FOR PUBLIC COMMENT

Introduction

In the 21st century, advances in science and engineering (S&E) will, to a large extent, determine the rate of economic growth, quality of life, and health and security of the world. The conduct, communication, and use of S&E – all intrinsically global endeavors – are increasingly important in addressing many critical global, regional, national, and local issues. Advances in science and engineering that improve the human condition will increasingly depend on the ability to draw upon the best minds regardless of national borders. Throughout the U.S. and the world, science and engineering are increasingly recognized as key enablers for invention, innovation, and economic growth. Moreover, as demonstrated so convincingly by the Green Revolution instigated and initially funded by the Rockefeller and Ford Foundations, science and engineering can facilitate international as well as domestic progress on many critical societal problems. Building scientific and engineering capacity at home and abroad is one of the most effective ways to advance economically and prepare for current and future challenges.

Many pressing global challenges require work in S&E fields, and it would be nearly impossible to tackle them without international collaboration and cooperation. A few of the global challenges we face today include: building a more secure infrastructure in the wake of terrorist threats and actions; capacity building and technology dissemination in underdeveloped and developing countries; environmental change and degradation, especially global climate change which not only threatens coastal cities and agriculture but is likely to cause major economic and demographic change; improving weather forecasting and response to natural disasters to help cope with events such as the December 2004 tsunami in the Pacific and Hurricane Katrina; and the threat of widespread epidemics such as Avian influenza and AIDS. The next generation of scientists and engineers will lead the world in combating global problems of the future, and thus, their nurturing is a priority that the world cannot ignore.

International S&E partnerships can complement national capabilities and resources for the common good, increase S&E literacy for all people, and build science and engineering capacity in developing nations. For such collaborations to achieve their full potential, however, there must be short-term and long-term mutual benefits and shared risk. Accountability must be an integral part of planning for successful collaborations to assure supporters that research integrity is a priority and that funds are used appropriately. Strengthening scientific capacity and promoting the free flow of information in developing countries will not only expand their S&E enterprises, but will help those countries attain a higher quality of life by supporting greater social stability. International S&E partnerships have proven to be very effective in building S&E capacity, utilizing global scientific expertise, supporting international relations with developing countries, and addressing critical global challenges.

Through international S&E cooperation, the U.S. can provide leadership on many of these international challenges. For example, a high priority of the U.S. Government is the Global Earth Observation System of Systems (GEOSS), a global network that will enable coordinated observations, better data management, and increased data sharing. The success of GEOSS is highly dependent on meaningful and lasting international cooperation.

As funding and personnel devoted to S&E grow in countries around the world, so too has output from these activities, including scientific articles, patents, and high-technology products.[1] Even

as scientific excellence increases around the world, U.S. leadership in international S&E partnerships remains one of the key ingredients to global prosperity.

Summary of Board Activities

The importance of international science to the U.S. and the National Science Foundation (NSF) was signaled by Vannevar Bush in his 1945 report[2] that led to the establishment of the NSF with the recommendation: *The Government should take an active role in promoting the international flow of scientific information.* At about the same time, the United Nations recognized the importance of international science and established the United Nations Educational, Scientific and Cultural Organization (UNESCO)[3] to contribute to peace and security by promoting international collaboration through education, science, and culture. Through much of the 20th Century and today, the cause of international science and engineering has also been advanced by a host of non-governmental organizations including the International Council for Science (ICSU),[4] the World Federation of Engineering Organizations (WFEO),[5] and the Academy of Sciences for the Developing World (TWAS).[6]

Issues of international science and engineering are not new to the National Science Board. In 2000, the interim report: *Toward a More Effective NSF Role in International Science and Engineering* (NSB-00-217) made a number of specific recommendations to increase NSF's engagement and to achieve higher visibility in international research and education. The subsequent Keystone Recommendation in the November 2001 Board report, *Toward a More Effective Role for the U.S. Government in International Science and Engineering* (NSB-01-187), still remains fundamental:

> *The U.S. Government should move expeditiously to ensure the development of a more effective, coordinated framework for its international S&E research and education activities. This framework should integrate science and engineering more explicitly into deliberations on broader global issues and should support cooperative strategies that will ensure our access to worldwide talent, ideas, information, S&E infrastructure, and partnerships.*

The importance of this work is reinforced by the *National Science Foundation Investing in America's Future: Strategic Plan FY 2006-2011* (NSF-06-48) and in the *National Science Board 2020 Vision for the National Science Foundation* (NSB-05-142). In its vision document, the Board recommended NSF strengthen existing international and interagency partnerships and develop new partnerships.[7]

In 2005, the Board decided that shifts in the international landscape, along with the unfulfilled recommendations of its 2001 report, warranted a careful re-examination of the U.S. Government's role in supporting international science and engineering. Particular emphasis was placed on international S&E partnerships that can improve international relations, build scientific capacity, improve quality of life, and protect the environment.

The Board charged the Task Force on International Science (Task Force) in September 2005 to examine the role of the U.S. Government in international S&E partnerships and to focus on several key issues:[8]

- To facilitate partnerships between U.S. and non-U.S. scientists and engineers, both in the U.S. and abroad, and in developed and developing countries; and
- To utilize S&E partnerships for improving relations between countries and to raise the quality of life and environmental protection in developing countries.

The Board focused on issues related to partnerships with developing countries, but also considered the potential for the U.S. to partner with other developed nations to aid S&E conducted by developing countries. In determining how the U.S. can best move forward as a full partner in the current international scientific enterprise, representatives of the Board Task Force on International Science first met informally with individual federal agencies, NGOs, foundations, and other organizations. The Task Force then convened a formal public Roundtable Discussion in May 2006 at George Washington University in Washington, D.C. This forum enabled the Board to gain insight on the current and potential role of the U.S. Government in supporting international science and engineering.

The Task Force also met with the leadership of NSF and its Office of International Science and Engineering (OISE) to assess NSF's progress with the recommendations from the prior Interim Report *Toward a More Effective NSF Role in International Science and Engineering* (NSB-00-217). The Task Force was pleased to find substantial progress with all nine recommendations from the Interim Report and additional progress in such areas as the new Partnerships for International Research and Education (PIRE) program, a new international cyberinfrastructure program, continuing leadership in global scale research programs such as the International Polar Year (IPY), and significant participation by NSF in multilateral/international organizations engaged in science and engineering such as the International Institute for Applied Systems Analysis (IIASA), the Organisation for Economic Co-operation and Development (OECD), the International Council for Science (ICSU), the Human Frontier Science Program (HFSP), the World Meteorological Organization (WMO), United Nations Educational, Scientific and Cultural Organization (UNESCO), and the Organization of American States (OAS). Further, with respect to international partnerships, the Task Force was encouraged to learn of many bilateral S&E programs involving the Office of Science and Technology Policy (OSTP), the Department of State (DOS), the United States Agency for International Development (USAID), NSF, and various Federal Agencies to help achieve foreign policy abjectives. In addition to the U.S., nations participating in these S&E programs include Pakistan, India, Israel, China, Brazil, and Iraq. The NSF Inspector General also provided valuable insights into the challenges that governments face on research integrity and how to handle allegations of misconduct in research. Through the Global Science Forum, members of the Office of Economic Cooperation and Development have developed a strategy to promote integrity and deter misconduct throughout the scientific enterprise.

Based on the information obtained from the discussions and meetings in the United States, the Task Force met formally and informally with scientists and engineers around the world in order to gather additional insight on S&E initiatives and international partnerships that would enhance the Task Force's findings and recommendations. To obtain diverse perspectives, meetings were set up in Asia, Europe and the Middle East.

The first of three international gatherings was held in September 2006, when Task Force members traveled to Singapore to hold a round table discussion with representatives of the Industrial Science and Technology Working Group of the Asia-Pacific Economic Cooperation economies. This discussion provided important insights on the value of international S&E partnerships to other, particularly developing, nations and identified challenges faced by Asia-Pacific economies in developing and sustaining these partnerships.

A second discussion forum was held in March 2007 in Brussels with representatives from the European Commission and leaders in science and technology from the European Community to discuss the European experience with international partnerships. Interestingly, the new EU 7th Framework Programme (2007-2013) makes an explicit budgetary provision for international partnerships with developing countries and seeks to "mainstream" international cooperation throughout the programme. Discussions were also held with representatives from the Abdus Salam International Center for Theoretical Physics (ICTP) and the Academy of Sciences for the Developing World (TWAS) to learn their unique perspectives on the value of international S&E partnerships to improve the quality of life of, environmental protection and scientific capacity in, and relationships with, developing countries.

The final set of discussions were held in July 2007, when Task Force representatives traveled to the Middle East to better understand the power of science diplomacy to improve relations in this troubled part of the world. Discussions were held with the Board of Governors of the U.S.–Israel Binational Science Foundation (BSF) in Jerusalem, representatives from the Israeli-Palestinian Science Organization, the Director and staff of the Bibliotheca Alexandria (the modern successor to the ancient Library at Alexandria), HRH Princess Sumaya and the staff of the Royal Scientific Society in Amman, Jordan, and with many other individual scientists, university leaders and government representatives in Israel, Palestine, Egypt, and Jordan to learn of their experiences and needs in international science and engineering partnerships.

S&E Partnerships Serve as Instruments of 'Soft Power'

The term 'soft power' was first coined by Harvard University professor Joseph Nye in 1990 to refer to the ability of states to indirectly influence the behavior or interests of other states through an attraction to shared values or other cultural or ideological means. Successful use of soft power relies heavily on a state's reputation within the international community and the quality of flow of information between the states involved. International S&E partnerships can be important instruments of foreign policy where science and engineering serve as an important, apolitical soft-power bridge between nations. S&E partnerships can contribute to building more stable relations among communities and nations through cooperation and by creating a universal culture based on commonly accepted values of objectivity, sharing, integrity, and free inquiry. Science, technology, and engineering education can also be instruments for democratic and well-governed states by empowering good governance through meritocracy, open and free enterprise, and sound research.

On a similar note, Secretary of State Rice has introduced the concept of "transformational diplomacy" as striving to, "work with our many partners around the world to build and sustain democratic, well-governed states that will respond to the needs of their people -- and conduct themselves responsibly in the international system…Transformational diplomacy is rooted in

partnership, not paternalism -- in doing things with other people, not for them." Partnerships between collaborating scientists and engineers across national boundaries represent a particularly effective form of transformational diplomacy.

Throughout its meetings and discussions, the Task Force observed many successful S&E partnerships and selected the following key examples to demonstrate the benefits of international collaboration.

Scientific partnerships can be employed as a soft-power vehicle to achieve explicit foreign policy objectives. The U.S. Civilian Research and Development Foundation (CRDF) is an example of a non-governmental organization (NGO) dedicated to building international S&E partnerships. Congress created CRDF in the wake of the collapse of the Soviet Union to address problems that arose when thousands of scientists and engineers, many of them former weapons scientists, no longer had an outlet for their work. CRDF provided research grants, training, and exchange programs that enabled these scientists and engineers to continue making productive contributions in their fields and to participate in the rebuilding of their countries, while also building S&E partnerships with American counterparts. CRDF is now applying its programs and expertise in other regions of the world, including the Middle East and North Africa.

The U.S.–Israel Binational Science Foundation (BSF), the U.S.–Israel Binational Agricultural Research and Development Fund (BARD), and the Israel–U.S. Binational Industrial Research and Development Foundation (BIRD) were jointly endowed by the U.S. and Israel to organize, fund, and help achieve common goals for international partnerships in science, agriculture, and entrepreneurship. Additionally, the BSF Board of Governors recently called for Palestinian involvement in workshops sponsored by BSF, which emphasizes the power of science diplomacy to bring together otherwise very antagonistic populations. With support from the U.S. Department of State, regional scientific workshops have proved to be a very cost effective way of bringing scientists together around common issues in the Middle East and in other regions of the world. These regional scientific workshops should continue to be a high priority, but subsequent funding for actual research collaborations are also needed.

The USAID-funded Red Sea Marine Peace Park Cooperative Research, Monitoring and Management Program (RSMPP Program) serves as another good example of a multilateral Israel–Jordan–U.S. science partnership with great benefits to science, those nations, the region, and the pursuit of peace. Funding requirements for such partnerships are modest and pay substantial long-term dividends.

Egypt and the U.S. have also experienced great success in establishing collaborative partnerships under the aegis and support of the jointly funded Egypt–U.S. Joint Science and Technology Fund. Like the U.S.–Israel Funds referenced above, this fund represents an excellent example of science diplomacy that could well serve as a model for other bilateral and multilateral diplomatic relationships in the Middle East and elsewhere. Very recently, the U.S. established the Community College Initiative (CCI) with Egypt under the aegis of the Fulbright Commission. This innovative program will sponsor up to 200 Egyptians to study for up to two years at community colleges in the United States.

The U.S. and Jordan have recently signed an Agreement on Science and Technology Cooperation. However, unlike the agreements with Israel and Egypt, this agreement is not yet funded. In fact, only two of the forty-two S&T partnerships that the U.S. has established with other nations are funded. S&T agreements with no funding may well engender more frustration than good will. Some argue, however, that by developing relationships between scientists through the S&T working groups of the U.S. and partner countries, the best projects will rise to the surface and attract funding—there is no substitute for letting projects compete for a funding pool that already exists.

There are also important S&E partnerships in the fields of sustainable development and agriculture. The USAID Initiative to End Hunger in Africa (IEHA) defines science and technology as key to providing innovations that increase agricultural productivity while reducing vulnerabilities. This initiative encourages partnerships among U.S. universities, international researchers, and African researchers that invest in agricultural research, institutions, networking, and training in order to accelerate the development of science-based solutions for the problems of African farmers.

International centers serve as another means to build international S&E collaborations. Examples of these centers include: the Abdus Salam International Center for Theoretical Physics (ICTP) in Trieste, Italy, the International Centre for Pure and Applied Mathematics (ICPAM), the Trace Elements Institute of UNESCO, and the International Centre for Chemical Studies (ICCE). ICTP is supported by UNESCO, IAEA, and Italy to provide education and stimulate research in a wide variety of scientific fields for scientists in developing countries. With modest additional funding from other developed countries, this center could serve as an important broker to establish productive international collaborations between scientists and engineers in developed and developing countries. In the Southern African Millennium Ecosystem Assessment, the International Centre for Researching Agroforestry (ICRAF) works together with national research systems and NGOs to take a soil nutrient replenishment approach in rebuilding soil fertility.

S&E Partnerships and Capacity Building

One of the greatest benefits of international S&E partnerships between developed and developing countries is indigenous capacity building. Such capacity building improves the abilities of developing countries to be increasingly self sufficient and to participate more fully in the global enterprise to the benefit of citizens in developed as well as developing countries. A recent example of such capacity building is the Iraqi Virtual Science Library, developed by the U.S. Departments of State and Defense, which provides Iraqi researchers with the same access to scientific journals and research as one would expect on any university campus in the U.S. Developing scientific institutions in developing countries can also facilitate cooperation and communication. An example of this is the Africa Science Academies Development Initiative at the National Academy of Sciences, which demonstrates the benefit of taking a regional, in addition to a country-by-country approach, to increase the capacity of scientists in bringing their knowledge to policy debates.

A regional framework for capacity building is also exemplified in the assessment of the Caribbean Sea (CARSEA) of the Millennium Ecosystem Assessment,[9] which undertakes

integrated ecosystem analyses. This assessment aims to determine the policies and governance structures that will protect the ecosystem of the Caribbean Sea to sustain and supply services that support human wellbeing.[10] This collaboration will provide unique inter-disciplinary scientific and analytical information to protect the ecosystem function of the Caribbean Sea to the benefit of all involved participants, countries, and populations.

The new Library at Alexandria exemplifies a different kind of capacity building based on infrastructure development. This magnificent complex was established by Egypt in partnership with UNESCO, the EU, and a number of private sources near the site of the ancient Library; it includes a Planetarium, a Conference Center, and numerous research institutes and educational support facilities, in addition to, a modern library with extensive digital collections, data bases, archives and journals. The Library also provides extensive educational and research support services and stands as an important monument to the peoples of Egypt and other Arab speaking nations.

There are also many examples where NSF and USAID partner in supporting international S&T programs to facilitate capacity building. For example, the U.S.-Pakistan Science and Technology Program, led by a coordinating committee chaired by Dr. Arden Bement, NSF Director, and Dr. Atta-ur-Rahman, Pakistan Minister of Education and Science Advisor to the Prime Minister. USAID funds the US contribution of the joint program and also supports other programs in Pakistan involving NIH and other agencies. This US-Pakistan S&T program supports a number of joint research projects peer reviewed by NAS and approved by the joint S&T committee. Over the past year, the Committee has also established 16 S&T working groups that involve interagency participation in Pakistan and in the U.S. to carry out joint research projects of mutual interest (with direct benefit to Pakistan). Through this collaboration, NSF just completed a network connection of Internet 2 with Pakistan to facilitate research and education collaborations and data exchanges under the program.

Programs that recognize the benefits in promoting opportunities and careers for women in science and engineering can also contribute significantly to gender equity and other UN Millennium Development Goals. An example of how workshops can be used to build international collaboration-for both capacity building and gender equity-was the workshop held in Tunis in June 2007 on *Empowering Women in Engineering, Science and Technology*, which was sponsored by the World Federation of Engineering Organizations (WFEO) with support from the Tunisian Government and engineering organizations such as the Society of Women Engineers. Modest funding in these areas can result in substantial benefits to the U.S., other nations, and the international scientific enterprise.

There is also significant potential in partnerships between companies engaged in entrepreneurial business development. The U.S.–Israel BIRD Foundation is an excellent example of a facilitator organization for these venture industrial partnerships. And, the truly exciting aspect of these venture partnerships is that once seeded they have the potential not only to be economically self-sustaining, but also to generate additional funding for seeding future such enterprises.

Science Diplomacy

The Task Force's international meetings reinforced the notion that science diplomacy could facilitate relationships throughout the world whether it be in developed, underdeveloped, developing, or troubled regions. The most significant observations from these meetings were:

- Science and engineering with its common language, methods, and values has helped initiate and reinforce positive relations between peoples and nations with historic and deep seated enmities;
- A third partner from a "neutral" nation can help moderate the inevitable tensions that arise in partnerships between scientists, engineers, and educators from such nations;
- Educational and research partnerships can help developing nations in primary through post-doctorate education programs that develop science and engineering interests and competencies in young people;
- It is important that partnerships with developing countries be "catalytic" of positive future development and that these partnerships align well with national and regional needs and priorities;
- USAID and other fellowship programs of the 1960s and 1970s yielded large numbers of U.S. trained faculty and government leaders who are a strong voice for tolerance in conflict regions such as the Middle East; and,
- There is a strong dichotomy between the frustration peoples of the Middle East have with many aspects of U.S. foreign policy and their overwhelming regard and support for the stature of U.S. science, engineering, and higher education.

These observations lead to some inferences about U.S. foreign policy and its pursuit throughout the world with respect to science and engineering:

- Science diplomacy can be very effective in promoting communication between peoples and nations who otherwise are not disposed to cooperate;
- Evenhandedness is important – generous support for one nation can lead to frustration in others unless great care is exercised in explaining the apparent favored status (e.g. Jordanian frustration with perceived favored relationships the U.S. has with Israel and Egypt);
- While traditional diplomacy favors bilateral agreements, the regional character of many scientific and engineering challenges calls for multilateral approaches that engage all regional participants (e.g. The non-oil producing countries of the Middle East have common engineering and scientific priorities for water, energy, climate change, and transportation that might best be approached on a regional basis.);
- Just as regions can benefit from multilateral agreements with a funding nation such as the United States, so too, can funding nations benefit from entering into joint funding agreements – for example, opportunities for joint diplomatic and aid partnerships seem particularly strong between the United States and the European Union;[11]
- Regional S&E partnerships that have demonstrated positive impacts for improving regional relations should be encouraged with longer term funding commitments; and
- Many of the tensions between neighboring nations can be lessened through improved communication and trust, and U.S. diplomatic efforts should increase support of S&E partnerships as apolitical vehicles for improving communications and increasing trust.

Findings and Recommendations

A. U.S. Government Support for International S&E Partnerships

S&E research and development can be improved dramatically from international science and engineering partnerships. Through cooperative exploration, scientists and engineers gain access to foreign data, platforms, facilities, sites, expertise, information, and technology that can be utilized to advance the cause of science and engineering towards new knowledge. International S&E partnerships can lead to improved tools, models, products, and services due to global use, testing, and feedback to address issues of global concern. Such collaborations also lead to policy changes that directly influence outcomes in S&E partnerships at all levels.

As science and engineering become increasingly both global and competitive, it is critical to establish an environment for future generations of scientists and engineers to be able to perform in a more globally aware manner and environment. These future professionals will need to be more cognizant of, and able to successfully address, the various international and cultural issues that may influence the development and implementation of science and engineering partnerships. Establishing international networks of S&E collaborators in all nations may prove to be one of the most important qualifications for future researchers.

There are many examples of bilateral S&T programs involving bodies such as OSTP, the State Department, USAID, NSF leadership and interagency participation to achieve foreign policy objectives, however, more should be done to strengthen international S&E partnerships to provide an increasingly important means of keeping abreast of new insights and discoveries critical to maintaining U.S. strengths in key S&E fields.

It is essential that international scientific cooperation be understood as a high national priority. Therefore, the Board recommends:

> ***Recommendation 1***
> *The Office of Science and Technology Policy should work with the Department of State and the Office of Management and Budget (OMB) to make international S&E partnerships a priority for U.S. foreign policy and for U.S. R&D policy. Towards this end, OSTP should consider reestablishing the position of Assistant Director for International Strategy.*

Because science, engineering, and technology cooperation can be such effective routes of international diplomacy, the Board recommends:

> ***Recommendation 2***
> *The Department of State and USAID should do more to encourage and help fund S&E Partnerships as instruments of diplomacy that in turn create and help sustain more stable relationships among nations based on the universal language and values of science and engineering, which also help build the economic capacity of developing countries.*[12]

B. Removing Barriers in Building and Maintaining International S&E Partnerships

Stronger central coordination and leadership is necessary

No single U.S. agency is responsible for coordinating or supporting international S&E partnerships, and few U.S. S&E agencies have explicit missions in international relations, let alone in assisting developing countries. Thus, responsibility falls to individual S&E agencies to establish their own international research priorities and policies that promote their mission objectives. Fortunately, some inter-agency coordination is accomplished through information exchanges across various roundtables and panels that include representatives from different Federal agencies, but more needs to be done.

Coordination of U.S. international S&E partnership efforts of the various U.S. S&E agencies could benefit through an annual conference in Washington built around international science cooperation that includes NSF and the corporate and academic worlds in the process. The purpose of this conference would be to examine how on-going efforts could be made more transparent and better aligned, and duplication and overlap could be worked out on a cooperative basis. The National Academies may be an ideal body to organize such an annual conference.

The National Science and Technology Council (NSTC), a cabinet-level advisory council to the President for science and technology, also has a critical leadership role regarding international cooperation in science and engineering. NSTC should re-establish an inter-agency committee on international S&E in order to ensure that the U.S. is effectively leveraging an international S&E strategy to strengthen government missions and advance national economic, security, and sustainability goals. An important goal for this committee would be to prepare a composite budget which would include all the non-classified science, engineering and technology activities being sponsored by the U.S. Government in each country. This would help coordinate and focus international science and engineering efforts which the Board supports. To ensure that policymakers address both international policy for science as well as international science for policy, it is important to ensure active participation by the Office of Science and Technology Policy, the Department of State, and the U.S. Agency for International Development. The Board recommends:

> ***Recommendation 3***
> *Through the National Science and Technology Council, OSTP should re-establish a committee on international science and engineering to coordinate the activities of the Department of State, the U.S. Agency for International Development, and the various Federal Mission Agencies in international science and engineering.*

Designating a lead official within each federal agency that has an S&E component in their mission and providing them with tools to address international S&E cooperation would increase the U.S.'s ability to participate effectively in international S&E partnerships. Over the past several decades, most research-funding agencies have developed growing portfolios of activities at the international level. In the past, most such agencies relied on the transfer of funding and authority from USAID and the Department of State; today, many of them obtain authorization from Congress as well as small growing levels of appropriate funds for programs abroad. Notable in this regard is the international work of the U.S. Department of Health and Human Services (HHS) and its components such as the Centers for Disease Control and Prevention

(CDC) and the Fogarty Center at the National Institutes of Health (NIH). The international work of the U.S. Department of Defense (DOD) and the armed forces also has to be kept in mind when considering an inventory of this work across the Government. For purposes of coordination, the Board recommends that the focal point for this work be more clearly identified. This lead official would be responsible for creating a strategy for international S&E cooperation and for coordination across that agency and with other federal agencies. The Board recommends:

> ***Recommendation 4***
> *Each relevant federal agency should designate a lead official who is empowered to proactively encourage and develop international S&E strategy and coordination.*

The Government Performance and Results Act (GPRA) requires federal agencies to develop strategic plans, performance plans, and scheduled performance assessments. To ensure effective planning, execution, and accountability, relevant U.S. agencies should be directed to incorporate international science and engineering as a priority under GRPA. An international S&E strategy should be incorporated as one such priority for each agency under the GPRA guidelines to better ensure that the U.S. is gaining the value-added of a global planning perspective. Accordingly, the Board recommends:

> ***Recommendation 5***
> *Congress should amend the Government Performance and Results Act to require federal agencies to address strategy development and performance planning for international S&E partnerships, and OMB should include this in its Program Assessment Rating Tool PART[13] guidance to U.S. Federal agencies.*

Promote International Science Amidst Post-9/11 Security Measures

Unfortunately, some policies implemented or strengthened following the September 11th attacks have inhibited international S&E partnerships. Issues such as intellectual property protection, management and access to data, data representation policies, export controls, materials/technology transfer policies, standards, and visa policies all require careful discussion to foster the growth of U.S. participation in S&E partnerships, while protecting the security of the U.S. and its allies around the world. U.S. scientists and engineers, in dialogue with policy makers and students, must work together to create solutions for problems that transcend individual government agencies and research institutions.[14] Therefore, the Board recommends:

> ***Recommendation 6***
> *Congress should direct the Office of Science and Technology Policy, the Department of State, and the Department of Homeland Security (DHS) to balance U.S. security policies with the needs of international science and engineering including intellectual property protection, management and access to data, export controls, technology transfer, and visa issues.*

Encourage International Partnerships with Common Selection Criteria and Funding Processes

The bureaucratic overhead of dealing with the funding agencies of several countries involved in proposed international partnerships can discourage the participation of collaborating scientists despite the obvious scientific and societal benefits of such partnerships. The National Science Foundation has made good progress in employing common standards with the European Union, its Member States, and other developed countries. However, more needs to be done, particularly to ease the burden of establishing partnerships with scientists and engineers in developing countries. Specifically, progress and adoption of good practices in developing and employing common standards for international collaborative projects needs to be made across NSF. Some countries also have more restrictive policies regarding the ownership of intellectual property, which can complicate the formation of collaborative partnerships.

One avenue to decrease the potential of overly bureaucratic intervention in international engineering and scientific collaborations is to encourage partnerships with the accountability community so that common ground rules can be established. Currently efforts are underway to foster common research integrity values and definitions of misconduct in research, generally considered to be plagiarism, fabrication and falsification of data. On a global basis, scientific misconduct has grabbed the attention of various stakeholders, including the public, government and private funding organizations of research, publishers, and researchers themselves. A well-designed strategy to promote integrity and deter misconduct within international partnerships should be an integral part of all collaborative agreements. While there is no universally agreed upon methodology for accomplishing this, efforts are under way through the OECD Global Science Forum to develop models that may serve to facilitate accountability in international collaborations. These efforts are being supported by OSTP, NSF, and the NSF Office of Inspector General. The Board recommends:

> ***Recommendation 7***
> *The Office of Science and Technology Policy and the National Science Foundation should continue to work with their counterparts in other countries with significant partnership potential to institute common standards and processes: for the review and funding of proposed international science and engineering projects; to encourage other countries to establish common policies for granting ownership of intellectual property developed with government support; and to define common financial and compliance policies that establish best accountability practices to support international partnerships in S&E research.*

Increase Ability of Federal Agencies to Fund International Partnerships

Due to the global nature of U.S. national interests and the rapidly growing international scientific and engineering enterprise, many Federal S&E agencies already engage in international scientific and engineering partnerships to fulfill their individual mission objectives. For example, the Department of Defense (DOD) has a presence around the world with offices in Tokyo, Singapore, Chile, Argentina, and Australia. The National Science Foundation's Office of International Science and Engineering has representatives in Beijing, Tokyo, and Paris to facilitate mutually advantageous research collaborations. The work of agencies such as the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautic and Space Administration (NASA) is inherently trans-boundary in nature and global in scope.

Adequate funding is an important component of international S&E partnerships. Unlike the new EU 7th Framework Programme, the U.S. Government has no significant source of funds specifically appropriated for building international S&E partnerships on a global basis. Science, engineering and technology agreements between nations are often viewed as being no more than a statement of good intentions, because they lack funds to support research initiatives.

U.S. funding agencies have varying, but usually little, latitude in how they fund international institutions and partnerships between U.S. and non-U.S. researchers. However, DOD and the National Institutes of Health (NIH) are among the Federal agencies that regularly provide funding to international researchers for the purpose of conducting research with U.S. partners. Through the Fogarty International Center,[15] NIH can fund the best ideas related to global health regardless of origin. However, foreign scientists are asked to provide a justification of why U.S. tax dollars should be spent abroad.[16]

While the National Science Foundation encourages international S&E partnerships through its Office of International Science and Engineering which funds such projects and brokers additional funding from other directorates, NSF has limited funding for foreign collaborators. Discussions with scientists and engineers from developing countries suggest that even modest supplementary funding to cover their costs would greatly enhance their ability to participate in collaborative partnerships with U.S. scientists and engineers. Given its immense importance and very modest costs of these partnerships with developing countries, the Board recommends:

> ***Recommendation 8***
> *The National Science Foundation should better publicize its practice of encouraging PIs to request modest supplemental funding through their research grants for foreign collaborators from developing countries.*

Welcome and Engage International Science and Engineering Researchers and Students

The U.S. has always attracted many international students and researchers, but security regulations implemented after the September 11th attacks made it more difficult for foreign students and researchers to enter the country. The Department of State has done much to address these problems, but a perception continues to persist in the international community that the U.S. does not welcome non-U.S. scientists, engineers, and students as it once did. The Department of State recorded a decline in foreign students and researchers entering the country since September 11th,[17] and there is increasing concern that not enough American students are entering the S&E workforce or participating in international S&E education and research experiences.

The international scientific community is growing at a rapid pace, and the U.S. no longer leads the world in S&E publications. As centers of research excellence emerge across the world, more could be done to encourage U.S. researchers and students to take advantage of research and educational opportunities abroad. Recently, Japan and Australia have emerged as premiere funding countries of international S&E partnerships with the developing countries of Asia. The European Union has also been very active in funding collaborative S&E partnerships in the developing countries of the former Soviet Union, the Middle East, South America, and Africa.

In addition, South-South cooperation is promoting partnerships among developing countries with Brazil, China, and India.

With more foreign scientists and engineers encouraged to seek professional opportunities outside the U.S., a new pattern of international S&E partnerships and workforce migration is emerging. Instead of the 'brain drain' problem experienced by the developing world in the 1980s, a new environment is emerging that might best be described as "brain circulation." Many nations are encouraging scientists and engineers to leave their home countries to build bridges with foreign professionals leading innovative studies abroad. The idea is that these scientists and engineers will return home to their countries of origin, share their knowledge and networks with their fellow professionals, and assist in the building of capacity and infrastructure. One of the main impediments to more general adoption of this "brain circulation" model, however, is the lack of a supportive environment for junior scientists and engineers to encourage a return to their home countries.

Discovery and problem solving are often catalyzed by bringing together different expertise and varied perspectives, and enabling access to unique data and resources. Yet U.S. researchers who go abroad often find it difficult to achieve a position upon their return because they have lost ties to their domestic networks, which creates a disincentive for international research. Federal agencies should do more to encourage their engineers and scientists to participate in international exchange programs: these agencies should strengthen incentives for international training of U.S. scientists by establishing international research fellowships that include provisions to assist researchers in overcoming the financial burden of going abroad and by providing professional and research opportunities upon their return. There is also the need of global fora aimed to identify priority research infrastructures and develop common funding and governance schemes, where the development of large research infrastructures of a global nature could help in the circulation and return of U.S. scientists and engineers.

Therefore, the Board recommends:

> ***Recommendation 9***
> *Congress and the Department of State should facilitate "brain circulation", as opposed to "brain drain", in employing S&E talent to improve global quality of life and economic circumstances through:*
>
> - *Reinvigorating the interest of American students in S&E through support of study abroad opportunities with foreign scientists and engineers;*
> - *Streamlining the visa process for foreign S&E scientists, engineers and students;*
> - *Encouraging foreign study and collaborative scientific work of American scientists, engineers and students through incentives for return to the U.S. as well as the incentive of the work itself; and*
> - *Increasing use of U.S. and foreign specialized facilities for S & E.*

C. Opportunities for New Modes of Participation

The Role of Science in the Work of DOS and USAID

As noted previously, there is enormous potential for the Department of State and the U.S. Agency for International Development to employ science and engineering more aggressively in pursuit of their missions. In order to strengthen the partnership of science, engineering and diplomacy at USAID Missions abroad, and to more effectively advance science and engineering, the State Department should give S&E a higher priority in policy and elevate the role of Science Advisor at key U.S. embassies. The 2001 Board Report, *Toward a More Effective Role for the U.S. Government in International Science and Engineering*, made a similar recommendation encouraging the State Department to consider the importance of science and engineering in achieving the agency's objectives, and to identify mechanisms to improve communication and facilitate information sharing between science officers and U.S. embassy personnel both at home and abroad. Ambassadors overseas should also organize, where the size and scope warrants, a science committee in the Embassy built around membership of all the agencies who are present in the country and have a science, engineering or technology work program or activity. The Board recommends:

> ***Recommendation 10***
> *The Department of State should consider elevating the role and career paths of properly qualified Science Advisors at key U. S. Embassies to promote science, engineering and technology because of their many economic and quality-of-life benefits in improving global relations.*

In the past, USAID effectively leveraged capacity building in S&E to bring about widespread improvements to the stability and well-being of many countries in the developing world. The continuing advance of science and engineering offers an expanding horizon of possibilities for extending this mutually beneficial strategy. Unfortunately, the underdevelopment of the S&E infrastructure in many nations, combined with immediate imperatives for USAID to deal with conflict and disaster situations, has left longer-term efforts, such as S&E in capacity building, to flounder. USAID, with support of the executive and legislative branch, should recommit to this highly leveraged S&E capacity building mode of cooperation. Further, such collaborations have increasing potential to advance science and engineering across a wide range of frontiers as developing economies are home to the greatest biodiversity, climate sensitivity, and health challenges on the planet.

The success of previous USAID programs in populating universities in developing countries with U.S. trained faculty underscores the paucity of current programs in continuing this vitally important work. Aid monies spent in this way can be amazingly effective in enabling and constructively engaging future generations of young people, but the lead times are long and the consequences of under funding this important purpose will not be apparent for many years.

To address the influential role S&E should play in the USAID mission, the Board supports the key recommendations put forth in the National Academies report, *The Fundamental Role of Science and Technology in International Development: An Imperative for the U.S. Agency for International Development:*[18]

- USAID should reverse the decline in its support for building S&T capacity within important development sectors in developing countries; and

- USAID should strengthen the capabilities of its leadership and program managers in Washington and in the field to recognize and take advantage of opportunities for effectively integrating S&T considerations within USAID programs.

USAID should encourage other U.S. government departments and agencies with S&T-related activities in developing countries to orient their programs to the extent possible, in supporting the development priorities of host countries. USAID should also provide leadership in improving interagency coordination of activities relevant to development. The Board recommends:

Recommendation 11

The Administration and Congress should enact the recommendations of the National Research Council's report: The Fundamental Role of Science and Technology in International Development: An Imperative for the U.S. Agency for International Development to renew the once significant science and engineering capacity at USAID and encourage the Agency to better employ science, engineering and technology in fulfilling its international development charge.

USAID's mission is to further America's foreign policy interests while improving the lives of citizens of the developing world. Engaging developing economies with international science partnerships would fulfill NSF's mission and complement USAID's mission by:

- Promoting the progress of science and engineering by funding international researchers on the frontiers of new science;
- Sustaining and enhancing a cohort of U.S. trained university faculty and government leaders who can encourage understanding of U.S. values and policies to the next generation; and
- Advancing national health, prosperity, and welfare by using partnerships to solve problems of global concern.

Accordingly, the Board recommends:

Recommendation 12

The National Science Foundation should coordinate and cooperate more closely with USAID in support of international science and engineering partnerships intended to build capacity in developing economies.

NGOs Play an Important Role in International S&E

Many non-governmental organizations (NGOs) are partners in programs promoting societal benefit through science and engineering around the world. Industry, universities, and NGOs are uniquely positioned to facilitate international S&E partnerships with what should be leveraged for each partnership. For example, industrial partners allow the transition of technologies from the lab to the market. In addition, NGOs and universities frequently have a unique position in the international political environment that allows projects to be pursued regardless of the political situation among partners. These organizations often have more flexibility in working with governments and institutions that, for political reasons, do not want to be seen conducting

work with or on behalf of the U.S. Government. The Rockefeller and Gates Foundations, corporations such as Microsoft and Cisco and their foundations, the Abdus Salam ICTP, and the U.S.–Israel BSF are excellent examples of organizations that partner internationally in S&E.

One of the major challenges for developing and maintaining international programs such as IPY or IGBP is finding "glue money" for initial planning and continuing coordination of the programs. Currently, no body or organization views this issue – as opposed to funding specific projects - as their responsibility. Trying to get a multitude of national funding bodies to agree on joint funding for a strategic planning activity (e.g. that is high risk with no specific short term deliverable) is almost impossible. IPY is a very good example in this regard; it is a multi-billion dollar international program that was planned and is being held together on a shoestring. The U.S. needs to take the lead, in working with other nations, to provide adequate funding to NGO's (or other third parties) that are planning and coordinating international science and engineering programs, such as IPY. Accordingly, the Board recommends:

> ***Recommendation 13***
> *The Office of Science and Technology Policy, the Department of State, and other U.S. Federal agencies should work with non-governmental organizations and the private sector in utilizing S&E partnerships for improving relations between countries and improving the quality of life and environmental protection in developing countries.*

Conclusions

The U.S. Government supports international S&E partnerships for multiple beneficial reasons. However, little is really understood about the benefits of such partnerships both by the public and in Congress. The benefits of international science and engineering partnerships are not only vital to the future of the U.S., but also stand at the forefront of solving the most pressing issues facing the entire world. Climate change, natural disasters, food shortages, sanitation and drinking water, energy resources, and the spread of disease are only a few of the issues that have global consequences and require a collaborative global effort from not only scientists and engineers, but from policy makers at all levels. The U.S. is uniquely positioned to help shape the direction of international cooperation and provide leadership in building S&E partnerships that can address these important global issues.

In addition to addressing global challenges, U.S. leadership in international science and engineering partnerships would help ensure that the U.S. moves forward as a full partner in the global scientific and engineering enterprise. These partnerships can enable U.S. scientists, engineers, and students to participate more fully in the rapidly growing international scientific and engineering effort, which can in turn help the American business community stay on the cutting edge of technologies and help energize both the U.S. and the global economy. Robust and vibrant international partnerships and effective communication are also vital for Federal agencies to carry out their missions.

International S&E partnerships are also important tools of international diplomacy, strengthening international relationships and upholding many of the ideals that America holds dear:

accountability, meritocracy, transparency and objectivity. Economic development, cultivation of civil society, the elevation of the roles of women and underrepresented groups, and the redirection of scientists and engineering towards more productive, socially responsible pursuits are also indirect positive benefits of these partnerships. Likewise, international partnerships serve a crucial public diplomatic role. The U.S. puts its best face forward in international S&E partnerships where the rest of the world can see the U.S. as a great place to conduct science and engineering that also upholds strong values.

The U.S. Government currently plays an active role in supporting international S&E partnerships. However, that role could be performed far more effectively. In the U.S., no single agency is responsible for coordinating international S&E partnerships, in spite of the fact that some policy issues transcend individual agencies and require greater cross-agency coordination. Greater coordination of international S&E partnership activities among U.S. Federal agencies needs to occur, while respecting the autonomy of individual agencies.

Moreover, individual agencies have varying latitude in how they fund international institutions and partnerships between U.S. and non-U.S. researchers. Some domestic research funding agencies do not have adequate latitude to supplement international researchers and institutions from developing countries, where even very modest funding could make a tremendous difference, or to build creative mechanisms to support international S&E partnership programs. This is a key issue that must be addressed.

Finally, security measures put in place following September 11th have presented new challenges for international S&E collaboration. While the U.S. Government has made progress on these issues, further improvements are needed. The U.S. has to continue to attract the best and brightest from around the world, while also encouraging Americans to choose S&E careers. American researchers and students should be encouraged to take advantage of research and educational opportunities abroad (e.g. at centers of S&E research excellence). For the U.S. to continue to prosper, these global issues should be addressed now through international S&E partnerships as described in this report. As a Nation, we must not only face the challenges that require science and engineering expertise today, but we must be prepared to confront issues of global opportunity, and even survival, of the future.

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[1]National Science Board. 2006. *Science and Engineering Indicators 2006*. Two volumes. Arlington, VA: National Science Foundation (volume 1, NSB 06-01; volume 2, NSB 06-01A)., *pg. O-3.*

[2] Bush, Vannevar, *Science--The Endless Frontier*, A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, (Washington, DC: United States Government Printing Office, July, 1945).

[3] More information about the United Nations Educational, Scientific and Cultural Organization available online at: www.unesco.org

[4] More information about the International Council for Science available online at: www.icsu.org

[5] More information about the World Federation of Engineering Organizations available online at: www.wfeo.org

[6] More information about the Academy of Sciences for the Developing World available online at: www.twas.org

[7] National Science Board, *2020 Vision for the National Science Foundation* (Washington, DC NSB-05-142, 2005), p. 9. Available online at: http://www.nsf.gov/pubs/2006/nsb05142/nsb05142.pdf

[8]Committee on Programs and Plans Charge to the Task Force on International Science, September 29, 2005. (NSB-05-134). Available at http://www.nsf.gov/nsb/committees/is_charge.htm

[9] "The Millennium Ecosystem Assessment (MA) was called for by the United Nations Secretary-General Kofi Annan in 2000. Initiated in 2001, the objective of the MA was to assess the consequences of ecosystem change for

human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being. The MA has involved the work of more than 1,360 experts worldwide. Their findings, contained in five technical volumes and six synthesis reports, provide a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide (such as clean water, food, forest products, flood control, and natural resources) and the options to restore, conserve or enhance the sustainable use of ecosystems." See Millennium Ecosystem Assessment, *Overview of the Millennium Ecosystem Assessment*, (2005) at: http://www.millenniumassessment.org/en/About.aspx#1

[10] The lead institutions involved in this assessment are the University of the West Indies (UWI), the Cropper Foundation, the Institute of Marine Affairs (IMA), the Island Resources Foundation, the University of Florida, the Association of Caribbean States (ACS) Secretariat, the Caribbean Community (CARICOM) Secretariat, the Economic Commission for Latin America and the Caribbean for the Caribbean (ECLAC-POS) Office, the Caribbean Conservation Association (CCA), the United Nations Environment Programme Regional Office for the Latin America and the Caribbean (UNEP ROLAC), and the Caribbean Agricultural Research and Development Institute.

[11] Dr. Janez Potocnik, Commissioner for Science and Research for the European Commission, is actively seeking such partnering.

[12] The State Department, however, does provide support to UNESCO, OAS, and OECD for capacity building in developing countries, and NSF also provides direct leadership to all three of these international bodies.

[13] According to the Office of Management and Budget, PART was developed to assess and improve program performance so that the Federal government can achieve better results. A PART review helps identify a program's strengths and weaknesses to inform funding and management decisions aimed at making the program more effective. The PART therefore looks at all factors that affect and reflect program performance including program purpose and design; performance measurement, evaluations, and strategic planning; program management; and program results. Because the PART includes a consistent series of analytical questions, it allows programs to show improvements over time, and allows comparisons between similar programs. More information available online at: http://www.whitehouse.gov/omb/part/

14 "GAO has made several recommendations to strengthen the visa process in a way that reduces barriers for international students while balancing national security, and recent changes have improved the process. Processing times for certain security reviews have declined, and recent data show more student visas issued in the last few years. The Department of State also has taken steps to ease the burden on students, including expediting interviews and extending the length of time that some visa clearances are valid. The United States must maintain an appropriate balance between protecting national security interests and ensuring our long-term competitiveness. Monitoring current trends and federal policies is essential to ensuring that the United States continues to obtain talented international students in the face of greater global competition." Statement of George A. Scott, Director, Education, Workforce, and Income Security Issues, Testimony before the Subcommittee on International Organizations, Human Rights and Oversight, Committee on Foreign Affairs, House of Representatives, *Higher Education—Challenges in Attracting International Students to the United States and Implications for Global Competitiveness* (Washington, DC: U.S. Government Accountability Office, Friday, June 29, 2007).

15 More information about the U.S. National Institutes of Health's John E. Fogarty International Center for Advanced Study in the Health Sciences's Global Research Initiative Program for New Foreign Investigators (GRIP) available online at: http://www.fic.nih.gov/programs/research_grants/grip/index.htm.

[16] The Public Health Service Act provides authority to support direct awards abroad.

[17] According to the 2005 Survey of Graduate Students and Postdoctorates in Science and Engineering, co-sponsored by the National Science Foundation and the National Institutes of Health, total U.S. enrollment of foreign graduate students in science and engineering (S&E) fields continued to decline in 2005, but enrollment of first-time, full-time foreign S&E graduate students rose 4% over the 2004 level—the first increase since 2001. More information available online at: http://www.nsf.gov/statistics/infbrief/nsf07312/

[18] Committee on Science and Technology in Foreign Assistance, National Research Council, *The Fundamental Role of Science and Technology in International Development: An Imperative for the U.S. Agency for International Development.* (Washington, DC: The National Academies Press, 2006).